

Cleaner Technologies Substitutes Assessment Case Studies: Upholstered Furniture



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Alternatives to Chlorinated Solvent Adhesives in the Upholstered Furniture Manufacturing Industry

The Institute for Research and Technical Assistance (IRTA), a non-profit organization located in Santa Monica, California, analyzed the cost and performance of alternative adhesive technologies used by the furniture and sleep products industries. This project was sponsored by the U.S. EPA with a grant from the Design for the Environment (DfE) Program. The Cleaner Technologies Substitutes Assessment (CTSA) is a partnership with industry including Southern California Edison (SCE) and the Association of Woodworking & Furnishings Suppliers® (AWFS®).

Industry Description

Flexible slabstock polyurethane foam is produced by 23 companies in about 75 pouring plants in the United States. In 1997, approximately 830 million pounds of slabstock foam were produced. By 1998, slabstock foam production doubled to about 1.6 billion pounds.





About 10 percent of furniture manufacturers use adhesives to bond foam to fabric or wood.

About IRTA

IRTA is a nonprofit organization established in 1989 to assist companies in adopting low- and non-solvent technologies. IRTA provides technical assistance in general and precision cleaning, drycleaning, paint stripping and coating, adhesive and ink operations.

Flexible slabstock foam is fabricated (cut and shaped) into pieces to be used in carpet underlay, furniture, bedding, packaging, transportation seating, and other products where a durable and resilient cushioning material is required.

Many foam manufacturers are vertically integrated and have on- or off-site foam fabrication operations using the foam stock they manufacture. These flexible foam manufacturers fabricate about half of the foam produced in their own facilities. The other half is purchased by independent fabricators who cut and shape it into various products. There are approximately 350 foam fabrication plants in the United States. All foam fabricators perform fabrication services for other companies that manufacture bedding, upholstered furniture and other products.

Types of Upholstered Furniture Manufacturing Operations

Upholstered furniture manufacturers purchase foam from foam manufacturers or foam fabricators and they use the foam to manufacture their furniture. Some upholstered furniture manufacturers make home furniture, some make office furniture and some make both types of furniture. Other manufacturers make stadium seating or transportation seating for use in conveyances like buses; some of these companies also manufacture office chairs.

There are more than 2,600 upholstered home furniture manufacturers in the United States. Approximately 60 percent of these firms have fewer than 10 employees. Although all upholstered home furniture manufacturers use foam for their seat backs, arms, cushions and pillows, only about 10 percent of them use adhesives in their operations. They use the adhesive to bond foam to fabric and wood.

There are about 950 companies that manufacture wood and non-wood office furniture in the country. Approximately 90 percent, or about 850 of these companies manufacture seating. Perhaps 90 percent or 765 of them use adhesives in their process. They use adhesives to bond foam to fabric, wood, metal and plastic and to bond fabric to wood, metal and plastic. The vast majority of these companies have fewer than 25 employees.



The vast majority of home and office furniture manufacturers are small businesses.

There are about 14 stadium seating manufacturers in the United States. Thirteen of these manufacturers have fewer than 25 employees. There are 26 manufacturers in the United States that make seating for buses and other public conveyances. Some of these manufacturers also make stadium seating. About three-quarters of these companies have fewer than 25 employees. Stadium and transportation seating requires adhesives to bond foam to fabric, wood, metal and plastic.

Adhesive Alternatives

In the 1980s and early 1990s, most of the adhesive used by upholstered furniture manufacturers was based on 1,1,1-trichloroethane (TCA), a chlorinated solvent. TCA was an effective carrier for the adhesive because it evaporates rapidly leaving an instant bond, it is fairly low in toxicity, it does not have a flash point and it is not classified as a Volatile Organic Compound (VOC) that contributes to photochemical smog.

In the 1990s, TCA was designated as a class one ozone depleting substance and, in 1996, its production was banned for that reason. Although TCA inventory was still available, the chemical had become very expensive because of a Federal tax on ozone depleting substances. Virtually all adhesive formulators stopped making TCA adhesives and began offering adhesives based on methylene chloride (METH), also a chlorinated solvent. Like TCA, METH evaporates quickly, does not have a flash point and is not classified as a VOC. However, METH is a suspected carcinogen. In 1997, the Occupational Safety and Health Administration (OSHA) issued a regulation on METH that lowered the worker exposure level from 500 ppm to 25 ppm measured as an 8-hour time weighted average. The regulation also set an action level at 12.5

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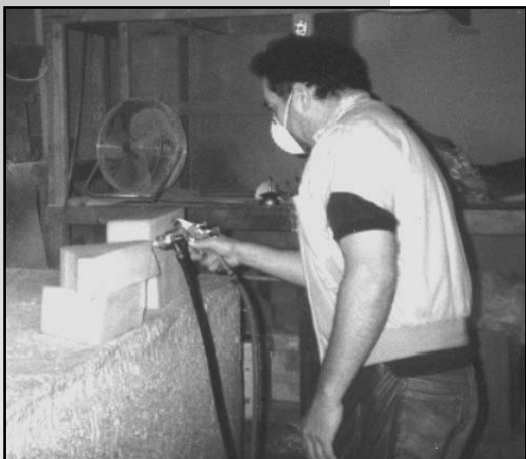


Office chair, stadium, and transportation seating requires adhesives to bond foam to fabric, wood, metal, and plastic.

About SCE

SCE, the flagship of the Edison International family of companies, is the nation's second largest investor-owned electric utility company. Central to the growth of the region's economy, SCE continues its decades-old commitment to assist businesses seeking to start, expand, or relocate to its service territory.

Water-based, acetone-based, and hot melt adhesives have been used as alternatives in upholstered furniture manufacturing.



ppm. Companies with worker exposure above that level are required to institute monitoring and medical surveillance.

In the early 1990s, the formulators developed one-part and two-part water-based adhesives and some upholstered furniture manufacturers, particularly in Southern California, adopted them. In Southern California, METH is classified as a toxic and could not be used when the formulators stopped using TCA adhesives. The early one-part water-based adhesives were based exclusively on natural latex and they did not bond instantly like the solvent-borne adhesives. The two-part adhesives were difficult to use in equipment but did bond instantly. They were much more expensive than the one-part adhesives, however. At this stage, new one-part water-based adhesives composed of natural latex and a small amount of synthetic polymers are available. These adhesives bond much more rapidly than the older one-part adhesives that are based exclusively on latex. Many California upholstered furniture manufacturers have converted or are converting to these new one-part latex/synthetic water-based adhesives. Some companies are still using the two-part water-based adhesives.

Another alternative in this industry is hot melt adhesives which are 100 percent solids. They are applied with special spray guns that heat the resins in the hot melt adhesives to 300 degrees F or higher so they can flow. Many upholstered furniture manufacturers, including those with automated lines, have adopted hot melt adhesives.

Another alternative is an adhesive based on acetone, a non-chlorinated chemical. Acetone is low in toxicity and, like TCA and METH, readily evaporates leaving a quick bond. It does have a very low flash point, however, and measures must be taken to minimize the chance of fire or explosion. The National Fire Protection Association (NFPA) has rated acetone as an NFPA 704 level 3 flammability hazard. State building codes and fire codes are based on NFPA guidelines. These codes vary according to location and local fire departments have regulations that affect the amount of the adhesive that can be stored and require explosion-proof motors and high air flow ventilation systems. Some formulations based on acetone also contain other chemicals like heptane, hexane and mineral spirits. The other chemicals in these formulations are classified as VOCs.

The best choice of adhesive differs by the type of product. The major alternative to METH- and TCA-based adhesives in the upholstered office furniture sector is hot melt adhesives. The major alternative in the upholstered home furniture sector is either one-part or two-part water-based adhesives. In the transportation seating sector, both hot melt and water-based adhesives are good alternatives. In some niche applications, manufacturers use acetone-based adhesives.

Manufacturers that use any of the adhesive types except hot melt adhesives generally need to install a ventilation system. Upholstered furniture manufacturers that wish to continue using METH-based adhesives have to purchase and install effective ventilation systems that reduce the worker exposure to the legal OSHA limit. Manufacturers that wish to use acetone-based adhesives must also install ventilation systems to ensure the acetone concentration is below the lower explosion limit of the chemical. Manufacturers adopting water-based adhesives generally install a ventilation system; the water-based systems produce aerosol particulates that can be removed from the workplace with the ventilation system.

About AWFS®

AWFS® was incorporated to fulfill a major need to represent the interests of companies and individuals who supply the home and institutional furnishings manufacturing industries. Today, AWFS® has an international membership that includes manufacturers and distributors of machinery, hardware, lumber, upholstery materials, bedding, wood products and other supplies to furniture and cabinet manufacturers.

Characteristics of Alternatives

Adhesive	Classified as VOC	Toxicity	Ozone Depleter	Flash Point	Issues
1,1,1-Trichloroethane	No	Medium	Yes	No	Production banned
Methylene Chloride	No	High	No	No	Heavily regulated
Acetone	No	Low	No	Yes	Fire regulations
Acetone Blends	Yes	Some high	No	Yes	Fire regulations
Water-Based	No	Low	No	No	Forms aerosols
Hot Melt	No	Low	No	No	High-temperature application

La-Z-Boy West a Pioneer in Water-Based Adhesives

The logo for La-Z-Boy, featuring the brand name in a bold, sans-serif, all-caps font. A registered trademark symbol (®) is located at the top right of the word "BOY".

La-Z-Boy West, part of the La-Z-Boy chain with 14 U.S. plants, established operations in Redlands, California in 1966. Today the Redlands facility has about 400 employees in a 190,000 square foot building that manufactures 800 pieces of furniture each day. In addition to the recliner chairs for which La-Z-Boy is famous, the firm also manufactures sofas, tables and office furniture. The Redlands plant manufactures 53 different styles in 30 different variants. A few years ago, the plant began making contract office furniture, a part of the business that is expected to grow substantially.

La-Z-Boy brings in the fabric, wood, metal and foam used to assemble the furniture. The Redlands operation includes three paint booths where a stain and one or two topcoats are applied. They also have three adhesives spray booths where adhesive is applied to

"The new water-based process is better from an environmental and worker exposure standpoint. The most important thing is that the process is technically effective."

bond foam to foam and fabric. The primary fabric used is muslin but some dacron and duon is employed as well. The foam is used to make chair seats, backs, arms and legrests.

In 1988, La-Z-Boy decided they wanted to convert from the solvent-borne coatings and adhesives they used at the time to water-based systems. They elicited the cooperation of their suppliers and also approached other suppliers. They spent the next three years testing water-based coatings and adhesives.

In January, 1992, the experimental work was completed and La-Z-Boy converted, in one shot, to a full water-based coating system and a one-part and two-part water-based adhesive system. More recently, La-Z-Boy has reassessed their adhesive system



La-Z-Boy West manufactures 53 different styles of furniture in 30 different variants.

and has now converted away from the two-part adhesive. All of the adhesives used in the plant today are water-based one-parts. According to Ted Meinke, Plant Supervisor, "We worked very hard on the conversions much earlier than other companies. We're pleased that we eliminated solvents from our plant."

In terms of the new adhesive system, Ted Meinke does not believe the company lost anything in the conversion. "Although there were problems with the two-part system, now that we're in the one-part system throughout, we've really minimized our costs."

At first, the workers did not like the water-based adhesives. They were used to solvents which have a very short tack time. Workers are paid by piecework and they did not want to wait between spray operations because it would reduce their pay. The employee charged with optimizing the conversion quickly figured it out. She could spray up two stacks of foam and by the time she was finished, she could begin bonding the first

stack. On balance, the throughput remained about the same even though the tack time of the water-based adhesives is longer. At this stage, all three of the adhesive sprayers, Mary, Rosalina and Sylvia, much prefer the water-based adhesives because of their reduced exposure to solvents.

The early efforts of the La-Z-Boy Redlands plant helped the company convert to water-based systems in their other plants nationwide. "The new water-based process is bet-



La-Z-Boy recliners like this one are bonded using water-based adhesives.



The early efforts of the La-Z-Boy Redlands plant helped the company convert to water-based systems in their other plants nationwide.

ter from an environmental and worker exposure standpoint. The most important thing

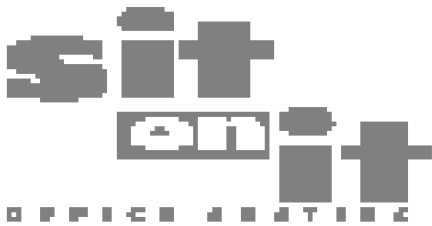
is that the process is technically effective," says Ted Meinke.

The cost comparison for La-Z-Boy for the TCA-based adhesives and the water-based one-part adhesives is shown below. The figures account for the fact that La-Z-Boy's production has increased since 1992 when the plant converted away from the TCA-based adhesives. The values show that use of the water-based adhesives is 35 percent less costly than use of the TCA-based adhesive.

Says Tony Freitas, a Production Supervisor involved heavily in the conversion, "I wouldn't want to convert back to the solvent-based glue even if we could. The water-based system we have today is great."

Annual Cost Comparison for La-Z-Boy		
	TCA-based Adhesive	Water-based Adhesive
Capital cost	—	\$120
Adhesive cost	\$28,800	\$15,840
Labor cost	\$113,400	\$113,400
Maintenance cost	\$1,800	\$4,914
Electrical cost	\$1,080	\$3,600
Training cost	—	\$227
Regulatory cost	\$1,193	\$528
Production adjustment	\$1,455	—
Total cost	\$212,827	\$138,629

Office Chair Manufacturer Starts Up with Hot Melt Glues



"Hot melt adhesives were the right choice for us.

We've been able to expand and do the right thing for the workers and the environment."

Mike Mekjian started a new business in February 1996. The company, called Sit-On-It, manufactures office chairs and is located in Brea, California. Between 100,000 and 200,000 chairs are manufactured each year and the company is one of the top 25 office chair manufacturers in the country. Today, Sit-On-It has a 31,000 square foot facility with 60 employees.

"I worked at another larger office furniture



Established in 1996, Sit-On-It has grown to 60 employees at its Brea, California plant.

manufacturer for several years," says Mike Mekjian. While he was there he analyzed a variety of different gluing processes that used 1,1,1-trichloroethane, methylene chloride, water-based and hot melt adhesives. "When I started up Sit-On-It, I wanted it to be completely clean from the beginning so I decided to go with hot melt adhesives," says Mike Mekjian. "I didn't want environmental problems down the line."

In the office chair production process, Sit-On-It bonds foam to wood and fabric. Particularly for bonding foam to wood, an aggressive adhesive is needed. In bonding the foam to fabric, the adhesive must have a two to three minute "open time." This allows a period for the workers to adjust the foam and fabric properly. This is especially important when the fabric has patterns or a geometric design. Another requirement for the adhesive is that it have a high heat

release rate. This is to ensure that high temperatures would not reactivate the adhesive. The company has changed glues three times to get the hot melt with the best properties for their application.

Originally the company applied all the adhesive in a batch operation. Last year Sit-On-It purchased a conveyORIZED system. At this stage, about 30 percent of the bonding is done on a manual line and 70 percent on an automated line. All of the foam to wood bonding is done on the conveyor line. Pressure is applied and the glue dries instantly. Then the conveyor applies glue to the foam and to the fabric. Four workers

Sit-On-It uses an automated hot melt line in its office chair production process.



Annual Cost of Hot Melt Adhesives for Sit-On-It

Capital cost	\$8,150
Adhesive cost	\$93,700
Labor cost	\$88,000
Maintenance cost	\$440
Electrical cost	\$2,580
Gas cost	\$60
Total cost	\$192,930

staff the three upholstery assembly stations where the foam and fabric are adjusted properly.

"We grew 600 percent in 1997 and 300 percent in 1998," says Mike Mekjian. "The investment in the conveyor line was worthwhile. It's very efficient. Hot melt adhesives were the right choice for us. We've been able to expand and do the right thing for the workers and the environment," he says.

Bus Seating Manufacturer Searches for Alternative Adhesive



American Seating manufactures transportation, office and auditorium seating at their production plant in Grand Rapids, Michigan. The company has 700 employees today and has operated at the same location since 1888. American Seating has a 95 percent market share in the manufacture of seats for tour and inner city buses; about 200 employees work in the transportation seating division. They also manufacture auditorium and sports seating, seats for colleges and major league teams. The company production amounts to between 500 and 1,000 seats per day.

American seating uses slabstock polyurethane and molded foam in their bus seating. Their operations involve bonding foam to metal, foam to vinyl, foam to fabric, vinyl to metal and vinyl to fabric. The prod-

"If we could use a water-based glue, it would be better for the workers, the community, and the environment."

uct used by the company currently is a solvent-borne adhesive containing acetone and various other organic solvents. Two or three people apply adhesive during the two 12-hour shifts the company operates.

American Seating has been testing alterna-



American Seating Company provides seating for stadiums and auditoriums like the Fulton County Governmental Building—Assembly Hall in Atlanta.



Operations at American Seating involve bonding foam to metal, vinyl, and fabric, as well as bonding vinyl to metal and fabric.

tives to their solvent-based adhesives for years. They would like to identify a suitable water-based alternative. The water-based products they have tested give good results in bonding foam to metal and foam to vinyl but not for vinyl to metal. The "green strength" or bond strength of the water-based adhesives they have tested so far do not meet the company's standards. The company has also tried hot melt adhesives that did not bond well to the metal.

"We would convert to a water-based adhesive tomorrow if we could find one that met our requirements," says Warren Zimmerman, Manager of the Production Operations Group. "We're not happy with a solvent glue. If we could use a water-based glue, it would be better for the workers, the community and the environment," he says.



Transportation seating provides challenges for adhesive alternatives.

Annual Cost of Solvent Adhesives for American Seating

Capital cost	—
Adhesive cost	\$65,875
Labor cost	\$117,000
Maintenance cost	\$1,903
Electrical cost	\$11,520
Total cost	\$196,298

Public Seating Company Converts Away From Solvent Adhesive



Country Roads is located in Greenville, Michigan. During the winter, the company has 80 employees that work one shift. During the summer, Country Roads hires 40 additional workers and the company operates two shifts.

Country Roads manufactures and remanufactures public seating for arenas, auditoriums and theaters. During the refurbishing process, the seats are pulled apart. All of the metal and most of the wood they contain is reused in the process. New foam and fabric are used on the refurbished seats which are put back in use. The company remanufactures about 200,000 chairs a year.

As part of the refurbishing process, the company used a methylene chloride-based glue to

"The hot melt glues look very good for most of our production...We're going to make a full conversion away from methylene chloride."

bond foam to wood, foam to steel, foam to fabric, steel to fabric and foam to vinyl. Three workers apply the adhesive in two spray booths. The company started aggressively investigating alternatives in the last year. After a significant amount of testing, the company found that hot melt glues best satisfied their requirements for about 90 percent of their production. The company is in the process of converting from the METH-based adhesives to the hot melt glues.

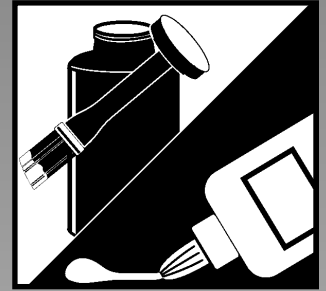
"The hot melt glues look very good for most of our production," says Dave MacMillen, Plant Superintendent at Country Roads. "We still need a good adhesive for bonding plastic to metal," he says. "We plan to test

an acetone glue for those applications. We're going to make a full conversion away from methylene chloride."

Annual Cost of Methylene Chloride Adhesives for Country Roads	
Capital cost	—
Adhesive cost	\$25,300
Labor cost	\$179,200
Maintenance cost	\$396
Electrical cost	\$360
Total cost	\$205,256

About the Design for the Environment (DfE) Program

The Design for the Environment (DfE) Program is a cooperative effort between the Environmental Protection Agency (EPA), industries, research institutions, environmental/public interest groups, and other government agencies. Working with these partners, the DfE program identifies cost-effective alternatives to existing products and processes that reduce risks to workers and the environment while maintaining or improving performance and product quality. Through the DfE program, EPA encourages businesses to incorporate environmental considerations into their products, processes, and technical and management systems. To help industry implement some of the ideas and technologies identified, the DfE program has published a number of case studies of companies which have found that environmental improvements can also lead to economic benefits. The case studies encourage other vendors, as well as other businesses, to learn from these environmental successes and adapt the techniques to their own processes.



Check Out DfE's Adhesives Web Site:

[http://www.epa.gov/opptintr/
dfe/adhesive/adhesive.html](http://www.epa.gov/opptintr/dfe/adhesive/adhesive.html)

For More Information

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